

Patent claims

1. A method for forming a functional layer on an inorganic or organic substrate, wherein

a) a low-temperature plasma, a corona discharge, high-energy radiation and/or a flame treatment is caused to act on the inorganic or organic substrate,

b) 1) at least one activatable initiator or 2) at least one activatable initiator and at least one ethylenically unsaturated compound is/are applied in the form of a melt, solution, suspension or emulsion to the inorganic or organic substrate, there being incorporated in the activatable initiator and/or the ethylenically unsaturated compound at least one function-controlling group which results in the treated substrate's acquiring desired surface properties, and

c) the coated substrate is heated and/or is irradiated with electromagnetic waves, the substrate thereby acquiring the desired surface properties.

2. A method according to claim 1, wherein the function-controlling group is composed as follows:

- i) a hydrophilic or hydrophobic group for controlling hydrophilicity/hydrophobicity,
- ii) an acid, neutral or basic functional group for controlling acid/base properties,
- iii) a functional group having high or low incremental refraction, for controlling the refractive index,
- iv) a functional group having an effect on the growth of cells and/or organisms, for controlling biological properties,
- v) a functional group having an effect on combustibility, for controlling flame-retardant properties, and/or
- vi) a functional group having an effect on electrical conductivity, for controlling anti-static properties.

3. A method according to claim 1 or 2, wherein as hydrophilic group there is used a polar group, such as an alcohol, ether, acid, ester, aldehyde, keto, sugar, phenol, urethane, acrylate, vinyl ether, epoxy, amide, acetal, ketal, anhydride, quaternised amino, imide, carbonate or nitro group, a salt of an acid, or a (poly)glycol unit.

4. A method according to at least one of the preceding claims, wherein as hydrophilic group there is used acrylic acid, acrylamide, acetoxy styrene, acrylic anhydride, acryl succinimide, allyl glycidyl ether, allyl methoxyphenol, polyethylene glycol (400) diacrylate, diethylene glycol diacrylate, diurethane dimethacrylate, divinyl glycol, ethylene glycol diglycidyl ether, glycidyl acrylate, glycol methacrylate, 4-hydroxybutyl methacrylate, 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, N-(2-hydroxypropyl)methacrylamide, methacryloxyethyl glucoside, nitrostyrene, sulfoethyl methacrylate, sodium salt of 3-sulfopropyl acrylate, 4-vinylbenzoic acid, vinyl methyl sulfone, vinylphenylacetate or vinylurea.
5. A method according to at least one of the preceding claims, wherein as hydrophobic group there is used a non-polar group, such as a branched or unbranched alkane, alkene, alkyne, partially or fully halogenated alkane or alkene or alkyne, alkylated amine, linear or branched silane or siloxane group or a partially or fully halogenated aromatic or non-aromatic cyclic group.
6. A method according to at least one of the preceding claims, wherein as hydrophobic group there is used tert-butyl acrylate, styrene, butyl trimethoxysilane, cyclohexyl acrylate, decanediol dimethacrylate, divinylbenzene, 2-(2-ethoxyethoxy)ethyl acrylate, 1H,1H-heptafluorobutyl acrylate, benzyl acrylate, 1H,1H,7H-dodecafluoroheptyl methacrylate, naphthyl acrylate, pentabromophenyl acrylate, trifluoroethyl acrylate or vinyltriphenylsilane.
7. A method according to at least one of the preceding claims, wherein as a functional group controlling acid/base properties there is used a carboxylic acid, sulfonic acid, phosphoric acid, sulfuric acid, phenolic acid or amino acid group or an amino, pyridine, pyrimidine, piperidine, pyrrole or imidazole group.
8. A method according to at least one of the preceding claims, wherein as a functional group controlling acid/base properties there is used allylamine, 2-aminoethyl methacrylate, 4-vinylpyridine, vinylpyrrolidone, vinylimidazole, morpholinoethyl acrylate, acrylic acid, 2-propene-1-sulfonic acid, sorbic acid, cinnamic acid or maleic acid.

9. A method according to at least one of the preceding claims, wherein as a group controlling the refractive index there is used a benzyl group, a partially or fully halogenated benzyl group or a partially or fully halogenated alkane or alkene or alkyne group.
10. A method according to at least one of the preceding claims, wherein as a group controlling the refractive index there is used benzyl acrylate, 1H,1H,7H-dodecafluoroheptyl methacrylate, 1H,1H-heptafluorobutyl acrylate or trifluoroethyl acrylate.
11. A method according to at least one of the preceding claims, wherein as a group controlling biological properties there is used a group having anti-fouling properties, such as copper(II) methacrylate, dibutyltin maleate, tin(II) methacrylate or zinc dimethacrylate.
12. A method according to at least one of the preceding claims, wherein as a group controlling biological properties there is used a group that promotes the growth of biological systems, such as a succinimide, glucoside or sugar group.
13. A method according to at least one of the preceding claims, wherein as a group that promotes the growth of biological systems there is used N-acyloxsuccinimide or 2-methacryloxyethyl glucoside.
14. A method according to at least one of the preceding claims, wherein as a group controlling flame-retardant properties there is used a fully or partially chlorinated or brominated alkane or nitrogen- or phosphorus-containing group.
15. A method according to at least one of the preceding claims, wherein as a group controlling flame-retardant properties there is used tribromoneopentyl methacrylate, bis(2-methacryloxyethyl) phosphate or monoacryloxyethyl phosphate
16. A method according to at least one of the preceding claims, wherein as a group controlling anti-static properties there is used a tertiary amino, ethoxylated amino, alkanol amide, glycerol stearate, sorbitan or sulfonate group.
17. A method according to at least one of the preceding claims, wherein as a group controlling anti-static properties there is used 2-diisopropylaminoethyl methacrylate, 3-

dimethylaminoneopentyl acrylate or oleylbis(2-hydroxyethyl)amine, stearyl acrylate, vinyl stearate.

18. A method according to at least one of the preceding claims, wherein the inorganic or organic substrate is or comprises a synthetic or natural polymer, a metal oxide, a glass, a semi-conductor, quartz or a metal.

19. A method according to at least one of the preceding claims, wherein the organic substrate is or comprises a homopolymer, block polymer, graft polymer and/or copolymer and/or a mixture thereof.

20. A method according to at least one of the preceding claims, wherein the organic substrate is or comprises a polycarbonate, polyester, halogen-containing polymer, polyacrylate, polyolefin, polyamide, polyurethane, polystyrene, polyaramide, polyether or polysiloxane / silicone.

21. A method according to at least one of the preceding claims, wherein the initiator is a compound or combination of compounds from the classes of the peroxides, peroxydicarbonates, persulfates, benzpinacols, dibenzyls, disulfides, azo compounds, redox systems, benzoins, benzil ketals, acetophenones, hydroxyalkylphenones, aminoalkylphenones, acylphosphine oxides, acylphosphine sulfides, acyloxyiminoketones, peroxy compounds, halogenated acetophenones, phenyl glyoxylates, benzophenones, oximes and oxime esters, thioxanthones, ferrocenes, titanocenes, sulfonium salts, iodonium salts, diazonium salts, onium salts, borates, triazines, bisimidazoles, polysilanes and dyes, and also corresponding coinitiators and/or sensitisers.

22. A method according to at least one of the preceding claims, wherein the initiator has at least one ethylenically unsaturated group, especially a vinyl, vinylidene, acrylate, methacrylate, allyl or vinyl ether group.

23. A method according to at least one of the preceding claims, wherein the ethylenically unsaturated compound is used in the form of a monomer, oligomer and/or polymer.

24. A method according to at least one of the preceding claims, wherein the ethylenically unsaturated compound is a mono-, di-, tri-, tetra- or poly-functional acrylate, methacrylate or vinyl ether.
25. A method according to at least one of the preceding claims, wherein as the plasma gas there is used air, water, inert gas, reactive gas or a mixture of the afore-mentioned gases.
26. A method according to at least one of the preceding claims, wherein the liquid used in method step b) contains the initiator(s) in a concentration of from 0.01 to 20 %, preferably from 0.1 to 5 %.
27. A method according to at least one of the preceding claims, wherein the liquid used in method step b) contains the unsaturated compound(s) in a concentration of from 0.1 to 30 %, preferably from 0.1 to 10 %.
28. A method according to at least one of the preceding claims, wherein the liquids used in method step b) additionally comprise other substances, for example defoamers, emulsifiers, surfactants, anti-fouling agents, wetting agents and other additives customarily used in the coatings industry.
29. A method according to at least one of the preceding claims, wherein the thickness of the applied layer in the dry state ranges from a monomolecular layer up to 2 mm, preferably from 2 nm to 1000 μ m, especially from 2 nm to 1000 nm.
30. A method according to at least one of the preceding claims, wherein in method step c) irradiation is carried out using sources which emit electromagnetic waves of wavelengths in the range from 200 nm to 20 000 nm or by means of electron beams, optionally preceded by a drying step.
31. A method according to at least one of the preceding claims, wherein in method step c) irradiation is effected over the whole area or parts thereof.
32. A method according to at least one of the preceding claims, wherein in method step c) partial irradiation is effected and unexposed material is then removed.

33. A substrate having a functional layer, obtainable by a method according to at least one of the preceding claims.
34. A product that has been provided with a coating in accordance with any one of the preceding claims.
35. The use of a functional layer as an anti-fogging, anti-graffiti, anti-stick, anti-fouling or flame-retardant layer, or for adjusting the surface tension, wetting, the refractive index, anti-static properties, anti-frictional properties, acidity or basicity, or for improving the adhesion or growth of biological systems.***